



The Iron Pillar of Delhi — twenty-three feet high — consists of a single piece of iron and is tribute to the metallurgical skill of ancient India. It was constructed in the third or fourth century A.D. and has shown no signs of rusting. In the background is the Qutab Minar, a victory tower, 238 feet high, built more than seven hundred years ago.

Contemporary physical science is a flourishing discipline unifying our knowledge of the external world and producing as by-products technological marvels that enrich our lives and enlarge our capabilities. What in the last century were connected but distinct sciences like astronomy, biology, chemistry and physics have now become essentially one discipline with differences in emphasis. In this awe-inspiring march of knowledge, people from many lands and many cultures have participated. It is clear that science is universal: the same principles of chemistry or physics would operate in America as in India, the same in the northern and in the southern hemispheres. Though many of the origins of contemporary sciences can be attributed to the Western world, science itself is neither eastern nor western. Most of my colleagues from non-western countries would be surprised if I were to ask them: Is science western?

I have been a scientist for the better part of my life and I have learned, propagated and contributed to science much as my friends and collaborators, born and brought up in the west, have done. Does this not corroborate the assertion that science is universal?

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SINDUR AND SYMMETRY

by
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Photo: Courtesy Air India

Perhaps it does. But it is equally true that one's culture influences the way one relates to a discipline, the niche that one chooses within the discipline and the relative importance one assigns to discoveries and achievements of the discipline. In the past few years I have tried to engage various scientists in a dialogue to get a clear picture of how they function. But my efforts have not been very successful: people seem to have a public statement which differs significantly from their private statements, so much so that I do not really know which to accept. Perhaps I myself am not any different from them in that what I believe as my own orientation may differ according to the social context !

So I turn to history to see if it holds any clues relating to the cultural context of orientation to science. I am at once amazed by the achievements of old in India and by apparent gaps in the development. In a country which invented the zero and the decimal ("Arabic") notation for the natural numbers there is hardly any evidence of pure geometry being studied seriously. While algorithms and techniques of numerical computations were invented and applied with great effectiveness to astronomical calculations hardly any efforts were devoted to quantitative studies of physical forces.

Amongst physical sciences, while chemistry was pursued with meticulousness and great inventiveness (remember the rustless iron pillar in Delhi), pure physics as contrasted with engineering seems to have been treated in *vaisesika* and *cārvaka* schools as components of philosophic systems rather than as an empirical science. In fact the most striking feature of the development of science in ancient India has been the distance between physics and chemistry: physics is more akin to *yoga* and *nyāya* rather than to empirical sciences like chemistry and *ayurveda*. It is not that dealing with complex systems and systematizing

them, and developing rules governing such systematization, was not to their taste: Pānini's grammar is a monumental work which was far ahead of its time and is still the standard. We must look elsewhere for an understanding of this curiosity.

In contemporary physics two main pursuits may be identified. One pursuit is direct experimentation and the "explanation" of the empirical findings within a theoretical framework. This is an essential, and by far the most arduous task of science. The relevance is immediate and the advance in our knowledge is beyond question: we can almost see the march of science as new technological aids come to the aid of research in the laboratory. There is, however, another kind of work which complements this. In this pursuit we deal with the laws of science arrived at the first stage and consider these laws as empirical data and search for a context in which they can be "understood", unified and admired. One rather imprecise way of stating the distinction between these complementary pursuits is to say that the first pursuit provides us with knowledge of the world and the second gives us knowledge in relation to our points of view, the relation of intelligence to facts. I hasten to add that this is indeed a manner of speaking: most scientists function in both modes of research.

If we did take this point of view we may still ask: how come pure physics was not quantitative. Or rather, how come quantitative physical science was transmuted with technology ? I do not have a full answer to this, but I submit that it was due in part to the recognition that the essential scientific content of our knowledge of the physical world, according to the scientists of that time, was strongly dependent on the perspective, though the technical implications were unambiguous.

At the present time most practising scientists agree on the

validity and usefulness of quantum mechanics in physics and chemistry. There would be no ambiguity and no controversy about the experimentally verifiable prediction of quantum mechanics. Yet there is significant difference of opinion about the problem of measurement, what is the physical significance of the mathematical apparatus of quantum theory. (As someone put it: It is a good thing that quantum mechanics is not built on its foundations !)

Yoga and *vedānta* were practised as empirical and experiential disciplines. But even within *vedānta* the emphasis and theoretical formulations could be quite different between two exponents who could however agree on all experiential matters. Is it possible that ancient Indian scientists separated the theoretical formulation of physics from its experiential content and put them as elements of separate disciplines ?

I feel inclined towards this view from the following considerations: even the humbler *jyotiṣis* are adept at calculations of eclipses and sidereal motions with what my training would indicate to be rudimentary accessories. How could such a tradition not be able to figure out the simpler laws of dynamics or introduce quantitative descriptions into physical phenomena ? There must be a value judgement involved, a different orientation to knowledge.

It is consistent with this view that a Copernican controversy did not arise in India. The relativity of frames is an aspect of our traditional knowledge.

What does it hold for the future ? I believe it promises the possibility that once this cultural influence is accepted (rather than vehemently denied) perhaps we could enrich human knowledge by reinstating the observing intelligence in the search for knowledge.

I expect other scientists to differ in view from me. It would be worthwhile to have other points of view articulated. ■